The Heart Surgery Forum #2003-151470
7 (1), 2004 [Epub December 2003]

Online address: www.hsforum.com/vol7/issue1/2003-151470.html

Immediate Extubation after Aortic Valve Surgery Using High Thoracic Epidural Anesthesia

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(#2003-151470 . . . October 17, 2003)

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ABSTRACT

Purpose: Fast-track anesthesia has gained widespread use in cardiac centers around the world. No study has focused on immediate extubation after aortic valve surgery. This study examines the feasibility and hemodynamic stability of immediate extubation after simple or combined aortic valve surgery using thoracic epidural anesthesia.

Methods: Thirty patients undergoing aortic valve surgery with an ejection fraction of more than 30% were included in this prospective audit. After insertion of a high thoracic epidural catheter, induction with fentanyl 2 to 4 μg/kg, administration of propofol 1 to 2 mg/kg, and endotracheal intubation facilitated by rocuronium, anesthesia was maintained with sevoflurane titrated according to bispectral index (target, 50). Perioperative analgesia was provided by high thoracic epidural analgesia (TEA) (bupivacaine 0.125% 6-14 mL/h). Hemodynamic data were compared by Friedman test. $P < .05$ was considered to show a significant difference. Data are presented as median (25th-75th percentile).

Results: Patients underwent simple aortic valve surgery (n = 17) or combined aortic valve surgery (n = 13) with additional coronary artery bypass grafting (n = 8), replacement of the ascending aorta (Bentall procedure) (n = 4), and repair of open foramen ovale (n = 1). All 30 patients were extubated within 15 minutes after surgery at 36.5°C (36.4°C-36.6°C). There was no need for reintubation. Pain scores were low immediately after surgery and 6, 24, and 48 hours after surgery at 0 (0-3.5), 0 (0-2), 0 (0-2), and 0 (0-2), respectively. During and up to 6 hours after surgery, there was no significant hemodynamic change due to TEA. Fifteen of 30 patients needed temporary pacemaker activation. There were no complications related to TEA.

Conclusions: Immediate extubation is feasible after aortic valve surgery with high thoracic epidural analgesia and maintenance of hemodynamic stability throughout surgery. Immediate extubation after aortic valve surgery is a promising new path in cardiac anesthesia.

Received October 10, 2003; accepted October 17, 2003.

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INTRODUCTION

Fast-track anesthesia has gained widespread use in cardiac centers around the world, mainly for coronary artery bypass surgery but also for valve surgery. Immediate extubation after coronary artery bypass grafting with [Royse 1999] or without [Djaiani 2001, Straka 2002] extracorporal circulation has been described. Advocates of high thoracic epidural analgesia (TEA) to facilitate fast-tracking techniques refer to the possible physiological advantages: better pulmonary function [Hendolin 1987, Fawcett 1997], enhanced pain relief [Williams 2002], and improved myocardial protection [Blomberg 1988, 1989a, 1989b, 1990a, 1990b, Kock 1990]. High thoracic analgesia has recently been used for fast tracking patients undergoing aortic valve surgery. Canto et al [2002] showed in operations on more than 300 patients that with TEA early extubation can be done safely in these patients. These investigators reported no neurological complications. Their study focus, however, was not immediate extubation, and no postoperative pain scores were presented. In addition, there was no clear indication of hemodynamic stability in these patients. Most textbooks, however, caution against the use of TEA in operations on patients with severe aortic stenosis. Many clinicians are taught to avoid reductions in afterload in patients with aortic stenosis. Therefore a study of TEA for immediate extubation of patients after aortic valve surgery has to examine several issues: success of extubation in the operating room, hemodynamic stability, and management of postoperative epidural analgesia because of imminent postoperative anticoagulation of patients receiving a mechanical valve. We undertook a prospective audit of 30 patients with an ejection fraction of at least 30% undergoing aortic valve surgery alone or in combination with other types of cardiac surgery. This audit focused on the hemodynamic stability of patients managed with TEA during and after surgery, the feasibility and success of immediate extubation, and postoperative analgesia.

PATIENTS AND METHODS

Patients and Procedures

Thirty patients with an ejection fraction of at least 30% undergoing aortic valve surgery performed by the same 2 surgeons and anesthetized by 3 anesthetic consultants were included in this prospective audit. All patients were visited before surgery and familiarized with the ultra–fast-track protocol (immediate extubation in the operating theater). All patients participated in consent discussions regarding immediate extubation in the operating room and regarding thoracic catheter insertion. It was explained to the patients that should arterial puncture during catheter insertion occur (determined with blood gas analysis), surgery would have to be delayed for at least 24 hours.

Patient Monitoring and Anesthetic Protocol

After the patient arrived in the operating room, 5-lead electrocardiography, pulse oximetry, and noninvasive blood pressure measurement were begun. A right femoral artery catheter was inserted for invasive blood pressure monitoring under local anesthesia. An epidural catheter was inserted at T3 or T4 under sterile conditions. A test dose of 5 mL lidocaine 1.5% with epinephrine was used to exclude intravascular position and to test efficacy of TEA. Induction consisted of fentanyl 2 to 4 μg/kg, followed by propofol 1 to 2 mg/kg and rocuronium 0.6 mg/kg. After endotracheal intubation, a right subclavian central venous catheter was inserted. Anesthesia was maintained with sevoflurane, titrated to maintain a bispectral index (BIS) of 50 (A-2000 BIS monitoring system; Aspect Medical Systems, Newton, MA, USA). Neuromuscular blockade was maintained with increments of rocuronium. Analgesia was achieved by TEA of bupivacaine 0.125% at 6 to 14 mL/h (started immediately after TEA insertion). One increment of 4 to 8 mL of bupivacaine 0.25% was given 10 to 20 minutes before incision, and one increment was given 10 to 20 minutes before extubation. Anticoagulation was achieved with 300 IU/kg of heparin and reversed with 1 mg protamine per 100 IU of heparin. During extracorporal circulation, anesthesia was maintained with propofol infusion titrated to maintain a BIS of 50. All thoracic drainage sites were infiltrated at the end of surgery with a total of 10 to 15 mL bupivacaine 0.25%.

Criteria for Extubation in the Operating Room

Extubation criteria were the following: a cooperative, alert patient; complete neuromuscular transmission as determined as train-of-four ratio of more than 0.8 at the adductor pollicis muscle; peripheral oxygen saturation of more than 96% on fraction of inspired oxygen of 50%, end-tidal carbon dioxide pressure <45 mm Hg, stable hemodynamics without inotropic support; absence of arrhythmias; and a core temperature (bladder) of more than 35°C. Pacemaker activation was not considered a contraindication to extubation.

Postoperative Care

Immediate extubation in the operating theater was followed by a short-term stay in the postoperative care unit.

Patient Demographics, Form and Severity of Aortic Valve Disease, Ischemic Time, Bladder Temperature, and Type of Valve*

Age, y	68 (58-73)
Sex, n, M/F	20/10
Weight, kg	75 (64-82)
Ejection fraction, %	60 (55-65)
Stenosis, n, severity	18, severe; 4, moderate
Regurgitation, n, severity	3, moderate; 5, severe
Cross-clamp time, min	55 (51-70)
Bladder temperature at extubation, °C	36.5 (36.4-36.6)
Mechanical/biological valve, n	19/11

*Values in parentheses are 25th to 75th percentile.

Two recovery nurses specially trained and familiarized with the ultra–fast-tracking program took care of all patients in a nurse-to-patient ratio of 1:1. All patients were to be transferred to the intensive care unit within 2 hours in stable hemodynamic and respiratory condition with sufficiently established analgesia. In the intensive care unit, a flexible nurse-to-patient ratio of 1:1 or 1:2 was used during an overnight stay.

Postoperative Analgesia

Postoperative analgesia consisted of TEA with bupivacaine 0.125% 6 to 14 mL/h and, for pain in areas not covered by TEA (e.g., lower extremities if additional vein grafting was performed), hydromorphone 0.5 to 1 mg subcutaneously.

Data Collection and Statistical Analysis

Patient demographic data, preoperative medical status, left ventricular function, and cross-clamp time were recorded. We recorded time to extubation and repetitive pain scores as measured with a numeric pain score at rest (0 = no pain, 10 = maximum imaginable pain) at the earliest possible time after surgery and then the highest score within 6 hours, 24 hours, and 48 hours after surgery. Intraoperative blood pressure and heart rate were recorded every 5 minutes before and after cross clamping. Postoperative blood pressure and heart rate were documented 2, 4, and 6 hours after surgery. Data from each recording time point were compared by Friedman test. If differences were found, a rank sum test was performed, and correction was made on the basis of number of comparisons. $P < .05$ was regarded as showing a significant difference. Complications, such as bleeding, hemodynamic problems (including the need for pacemaker activation), arrhythmias, and disorders of respiratory function, also were noted. Data are shown as median (25th-75th percentile) and, where noted, range.

RESULTS

Patient demographics are presented in the Table. Patients underwent simple aortic valve surgery (n = 17) or combined aortic valve surgery (n = 13) with additional coronary artery bypass grafting (n = 8), replacement of the ascending aorta (Bentall procedure) (n = 4), or repair of open foramen ovale (n = 1).

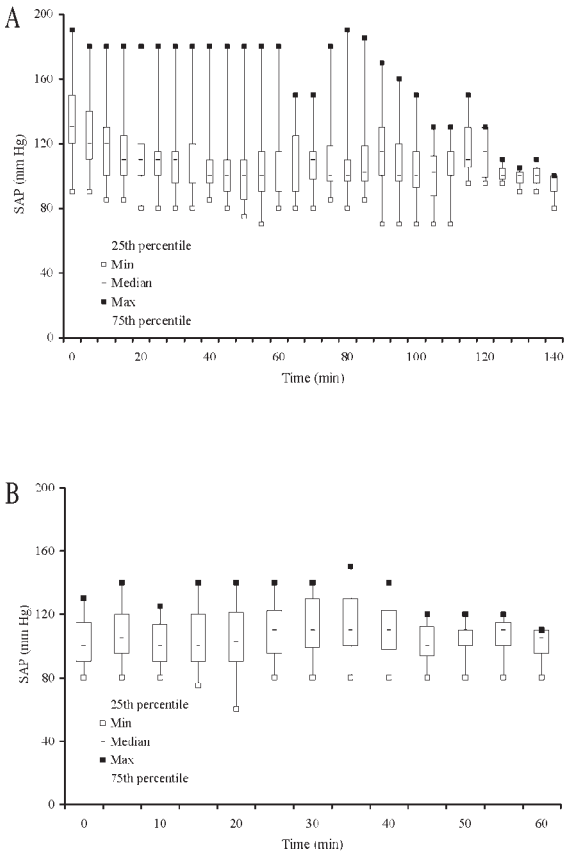

Figure 1. Systolic arterial pressure (SAP) before (A) and after (B) cross clamping. Min indicates minimum; Max, maximum.

All patients were extubated successfully. Extubation time was 14 minutes (12-15 minutes). Initial P_{O_2} and P_{CO_2} values were 160 mm Hg (123-194 mm Hg) and 46 mm Hg (44-48 mm Hg), respectively (FiO_2 = 1.0).

There was no significant difference in blood pressure or heart rate during or after surgery (Figures 1-4). During extracorporal circulation, blood pressure was kept between 50 and 80 mm Hg. No patient needed inotropic support to leave extracorporal circulation, and all patients were in hemodynamically stable condition at extubation. Fifteen patients needed temporary pacemaker activation after extracorporal circulation, which was discontinued in all patients within 24 hours after surgery. Postoperative pain scores were low immediately (within 30 minutes after extubation) and within 6, 24, and 48 hours after surgery at 0 (0-3.5), 0 (0-2), 0 (0-2), and 0 (0-2), respectively.

One patient with postoperative mediastinal bleeding needed repeated sternotomy 8 hours after surgery. He was extubated 4 hours after the second operation.

All patients were transferred to the intensive care unit 2 hours after surgery (1.8-2.2 hours). TEA was discontinued and the catheter removed in all patients 2.5 days (2.0-2.8; range, 1.5-5 days) after surgery. In 19 patients, postoperative anticoagulative treatment with warfarin was started more than 24 hour after surgery. In these patients, international normalized ratio (INR) factor tests were performed 3 times daily, and the epidural catheter was removed if INR was less than 1.5. In 2 patients, INR exceeded 1.5 at values of 1.8 and 1.9. In these cases the catheter was left in place, and further anticoagulative treatment was withheld until the next INR (9 hours later) was less than 1.5 and the catheters were removed. There were no cases of venous or arterial puncture, clinically apparent epidural hematoma, or neurological complications.

DISCUSSION

Immediate extubation is feasible after simple or combined aortic valve surgery using TEA. Postoperative respiratory function was good, as shown by high arterial P_{O_2} and low P_{CO_2} results immediately after surgery. High TEA did not lead to hemodynamic instability during or after surgery. Patient analgesia was excellent immediately and up to 3 days after surgery. There were no complications due to TEA.

In contrast to coronary artery bypass grafting, aortic valve surgery poses 2 additional problems: (1) greater risk of arrhythmias and (temporary) pacemaker activation and (2) greater risk of bleeding and need for postoperative anticoagulation after implantation of a mechanical valve or even a biological valve. The occurrence of bradyarrhythmias and need for pacemaker activation were equal to our previous experience in patients without TEA. Because pacemaker activation

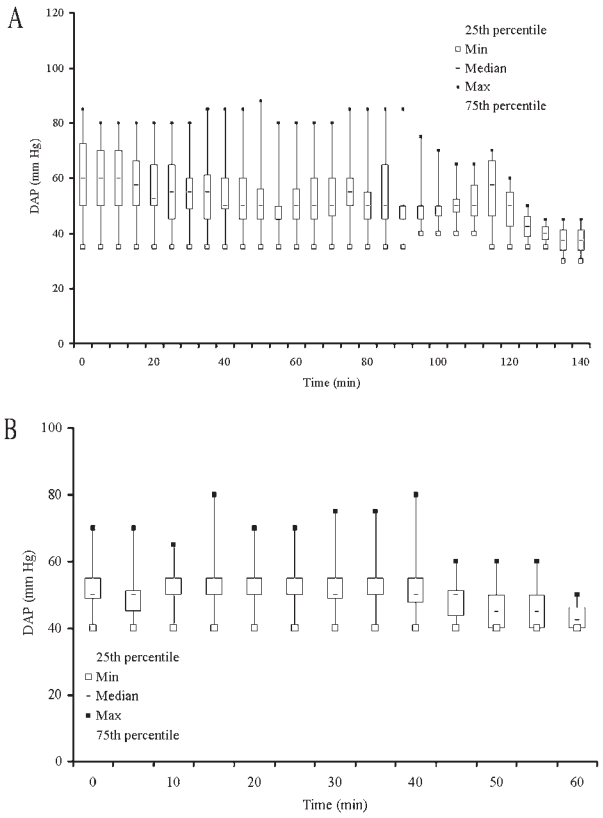

Figure 2. Diastolic arterial pressure (DAP) before (A) and after (B) cross clamping. Min indicates minimum; Max, maximum.

did not have a negative influence on hemodynamic stability, it was not considered a contraindication to immediate extubation. Pacemaker activation could be stopped in all patients within 24 hours after surgery. No patient needed permanent pacemaker implantation after surgery.

Postoperative anticoagulation is routine after implantation of a mechanical valve. In our setting, anticoagulation is begun with warfarin 24 hours or more after surgery. Because of this practice, effective anticoagulation is generally not achieved before 48 hours after surgery. We therefore decided to leave the catheter in place while narrowly controlling INR factor test results and removing the catheter before effective prolongation of INR (<1.5 seconds) [Horlocker 2003]. This policy means tight control of not only coagulation test results but also repetitive clinical assessment outcomes of these patients. In 2 patients, INR values were higher than 1.5 (1.8 and 1.9). In those patients, the catheter was left in place and removed when INR was less than 1.5.

Most textbooks caution against the use of general anesthesia for patients with aortic stenosis. The goal of anesthetic management of these patients is maintenance of sinus rhythm, systemic diastolic blood pressure, coronary perfusion, and cardiac output. However, maintenance can easily be achieved with careful TEA, as demonstrated by the hemodynamic stability in our patients. Starting continuous infusion of bupivacaine 0.125% almost 1 hour before sternotomy and careful timing of the first bolus so that its peak effect arrives at the time of sternotomy seem especially important for avoiding decreases in blood pressure and for achieving optimal stress protection. This strategy surely demands good cooperation between anesthesiologist and cardiac surgeon. In contrast to those for patients undergoing noncardiac surgery with aortic stenosis, the anesthetic considerations mentioned above should no longer be valid after extracorporal circulation and valve replacement.

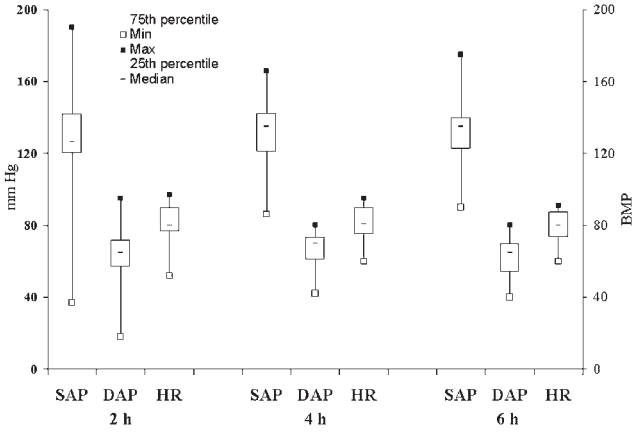

Figure 4. Systolic arterial pressure (SAP), diastolic arterial pressure (DAP), and heart rate (HR) 2, 4, and 6 hours after surgery. Min indicates minimum; Max, maximum.

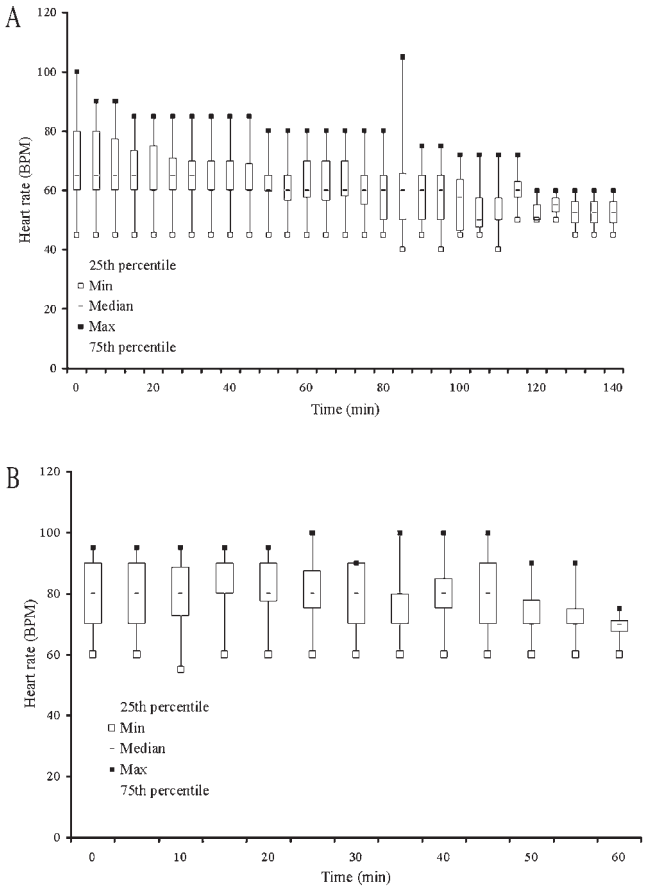

Figure 3. Heart rate before (A) and after (B) cross clamp. Min indicates minimum; Max, maximum.

Several studies examined immediate extubation after on-pump [Royse 1999] or off-pump [Djaiani 2001, Straka 2002] coronary artery bypass grafting surgery. Those studies concentrated on the feasibility of immediate extubation and stressed the importance of maintenance of core temperature, especially after off-pump coronary artery bypass grafting [Djaiaini 2001]. Royse et al [1999] presented results of immediate extubation using either conventional opioid-based analgesia or TEA. Immediate extubation was possible with both techniques, but pain scores after surgery were not given, and there was no evaluation of respiratory function after surgery. The same authors [Royse 2003] recently presented results of a randomized study comparing analgesia after coronary artery bypass surgery using either TEA or patient-controlled analgesia with morphine for fast-track anesthesia. The investigators observed better pain control, earlier extubation time, reduced risk of depression and posttraumatic stress, and improved physiotherapy cooperation in patients in whom TEA was used. The theoretical benefits of TEA in fast tracking anesthesia after coronary artery bypass grafting in comparison with opioid-based analgesia are described as superior analgesia [Williams 2002], better respiratory function [Hendolin 1987, Fawcett 1997], and better myocardial [Blomberg 1988, 1989a, 1989b, 1990a, 1990b, Kock 1990] and stress protection [Canto 2002]. Most studies show a superiority of TEA in comparison with opioid-based analgesia for postoperative pain control.

The benefits of TEA in facilitating immediate extubation and providing superior pain control make it our preferred technique for immediate extubation after cardiac surgery. Because our study was a feasibility study focusing on the specifics of using TEA for immediate extubation after aortic valve surgery, we did not include a control group without TEA.

There is still controversy about the risk of epidural hematoma after insertion of an epidural catheter and subsequent full anticoagulation. Evaluation of this risk was beyond the scope of this study; however, we believe that the risk of hematoma formation is small unless arterial puncture occurs, in which case surgery should be delayed for at least 24 hours [Williams 2002]. Risk calculations of epidural hematoma and neurological complications are difficult because with more than 5000 cases of TEA in cardiac surgery presented, no case of epidural hematoma has been described. In a recent study the risk of epidural hematoma was calculated as less than 1 in 500 [Ho 2000]. Canto et al [2002] described more than 300 patients undergoing aortic valve surgery with TEA. The investigators performed a neurologic risk evaluation and found that no patient had neurologic sequelae or clinically apparent epidural hematoma.

The key factors for minimizing risk of epidural hematoma have been described [Vandermeulen 1994] and were strictly followed in our study. These factors include normal results of preoperative coagulation tests, a waiting period of 60 minutes between epidural catheter insertion and anticoagulation, fewer than 3 tries, and use of a midline approach.

Economic aspects were not evaluated in this study; however, fast-tracking and ultra–fast-tracking techniques make it possible to change the nurse-to-patient ratio to 1:2 soon after cardiac surgery. It is also important to take into consideration that immediate extubation frees human and technical resources (no need for ventilation, ventilator setup, or respiratory therapists). Furthermore, the nursing staff can concentrate on pain control and control of hemodynamics and bleeding and other complications after surgery, thus providing better quality of care.

We present results for a pilot number of patients undergoing singular or combined aortic valve surgery and extubated immediately by application of techniques known for facilitating immediate extubation after coronary artery bypass grafting (use of short-acting anesthetics and TEA). The possibility of postoperative anticoagulation after aortic valve surgery necessitates tight control of clinical status and bleeding tests and removal of the epidural catheter when the INR is less than 1.5.

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